A New Perspective on Copper Age Technology, Economy and Settlement: Grinding Tools at the Valencina Mega-Site

Francisco Martínez-Sevilla, Leonardo García Sanjuán, José Antonio Lozano Rodríguez, Juan Manuel Martínez Jordán, Chris Scarre, Juan Manuel Vargas Jiménez, Ana Pajuelo Pando, Pedro López Aldana

Abstract

Activity patterns at large prehistoric sites are often difficult to interpret, as they frequently combine productive, domestic and funerary components. Valencina de la Concepcíon, the largest of the Copper Age mega-sites in southern Spain, has proved particularly challenging in this regard. Macrolithic tool assemblages have been generally neglected in these debates but can provide specific insight into the nature and patterning of activities. In this study, 185 grinding tools from seven separate excavations across this 450 ha mega-site were subjected to multiple lines of analysis including quantification, morphology, raw material, use-wear and depositional context. A surprising feature of this assemblage is the high degree of fragmentation, with more than half of the items representing less than 25% of the original artefact and only a small minority of them (<10%) complete. The absence of intact quernstones is particularly striking. The results indicate a ritualization of deposition at Valencina, and throw new light on the interpretation of this complex site. Furthermore. they emphasize the central role that grinding technology should play in future discussion of European prehistoric mega-sites.

Key words

Grinding technology, Lithic tools, Raw materials, Mega-sites, Copper Age, Iberia, Fragmentation

Resumen

Los mega-sitios constituyen un tema emergente en el estudio de la Prehistoria Reciente europea. Un número monográfico de Journal of World Prehistory aparecido recientemente reunió una serie de contribuciones que abordan los retos que estos sitios plantean en la investigación arqueológica actual. En este artículo analizamos Valencina, el mayor mega-sitio de la Edad del Cobre en Iberia, a través de un subconjunto de cultura material que ha sido bastante soslayado: la tecnología de molienda. A fecha de hoy, y a pesar de su omnipresencia y de su potencial para proporcionar datos relevantes sobre las formas de vida pasada, incluyendo redes de abastecimiento de materias primas, técnicas de manufactura, procesos técnicos, re-utilización y biografía de objetos, así como patrones de descarte y deposición, los útiles de molienda tan solo han jugado un papel secundario en el estudio del Neolítico y la Edad del Cobre en Iberia. Nuestra investigación, basada en un amplio muestreo de las colecciones de Valencina, proporciona una serie de indicios significativos en relación con todos esos aspectos, a la vez que arroja nueva luz para la interpretación de este complejo sitio. La discusión resultante enfatiza el papel central que la tecnología de molienda debería jugar en el futuro debate de los mega-sitios de la Prehistoria europea.

Palabras clave

Tecnología de molienda, Útiles líticos, , Materias primas, Mega-sitios, Edad del Cobre, Iberia, Fragmentación

1. Introduction

Mega-sites are an emerging topic in the study of European later prehistory, particularly the Neolithic and Copper Age. A recent monographic issue of *Journal of World Prehistory* (Gaydarska 2017) brought together a number of contributions discussing some of the most remarkable cases. These pose major challenges to current research, such as: what were the social practices leading to their formation? Were they home to early forms of massive but episodic gatherings entailing monument-building, conspicuous consumption and ritualised deposition (and destruction) of architecture and material culture? Or did they host early processes of permanent settlement formation, sometimes akin to proto-urbanism, within the context of economic intensification and wealth accumulation connected to increasing power institutionalisation? Were they the product of a combination of those two? The sheer materiality of mega-sites, often including large stone monuments, earthworks and staggering amounts of material culture and organic remains, is itself a challenge to archaeological research.

In this paper we aim to contribute to this important line of research by focusing on Iberia's largest Copper Age mega-site: Valencina de la Concepción–Castilleja de Guzmán (henceforth Valencina). Valencina is located in the lower Guadalquivir river valley (southwest Spain), within the metropolitan area of the city of Seville (Fig. 1 and 2). Extending over a large area of c. 450 hectares (3 km from north to south), Valencina is currently at the centre of the debate on the

Iberian Copper Age. This arises partly from the intrinsic features of the site (its large size, megalithic monuments, ditches, abundance of exotic raw materials, and remarkable craft production). It is also due to the evidence it provides for understanding aspects of the life-ways of third-millennium Iberia that were previously poorly known. These include temporality, settlement use and occupancy, economic production, craft specialisation, monumentality, competition, social inequality and long-distance interaction (for recent discussions see Nocete Calvo et al. 2008, 2013; García Sanjuán and Murillo-Barroso 2013; García Sanjuán et al. 2013, 2017, 2018a, 2018b; Cintas-Peña et al. 2018). A recent study has significantly expanded the chronometric data available for the site (García Sanjuán et al. 2018b). In summary, that study shows that after a relatively uneventful 'formation' period, between c. 3200 and 2900 BC, the site experienced a very substantial upswing between c. 2900 and 2700 BC, when it became the stage for grand occasions involving major ditch-digging and the construction of some remarkable megalithic tombs (first Structure 10.042-10.049, then Montelirio). The latter seem to have been built as part of intense dynamics of competition between corporate groups with access to a wide array of foreign exotica (ivory, cinnabar, ostrich egg-shell, rock crystal, etc.). After a short period of decline, the construction of megalithic monuments resumed with the erection of La Pastora and, perhaps, Matarrubilla, two remarkable tholos-type constructions, and further burial activity between c. 2650 and 2400 BC. In the 24th century BC activity at the site declined sharply, perhaps in connection with the environmental, economic and social consequences of the 4.2 ka BP climatic 'event'. More generally, within the long history of research on European Copper Age societies – see Pearce (2019) for a recent review – the Iberian evidence provides a broad range of fresh possibilities, with new types of site being discovered and excavated and new methods applied to their study.

With this in mind, our aim is to examine several of the issues concerning Valencina as a mega-site by looking at a set of material culture that, to date, has been largely neglected: grinding technology. Grinding tools are one of the most important components of the material culture of prehistoric societies. Querns and grinders, together with a broad spectrum of other tools including hammers, polishers, mortars and axes, form a major subset of prehistoric material culture: macrolithic tools (Adams et al. 2009). When referring to milling technology, we will use the term *quern* as a synonym for *grinding slab*, and *grinder* as a synonym for *handstone*, *rubber* or *mano* (Spanish for 'hand', used in American English and widely employed in Mesoamerican and North-American archaeology). The archaeological study of prehistoric macrolithic tools is comparatively more recent than that of knapped lithics (especially flint), which goes back to the 19th century. However, in the last four decades it has made great progress, demonstrating the potential to provide relevant data on past life-ways, including supply networks of raw materials, manufacturing techniques, technical processes, reuse and biography of artefacts, as well as patterns of discard and deposition (Horsfall 1987; Adams 1988, 1989; Lidström-Holmberg 1998; Treuil and Procopiou 2002; Risch 2002; Dubreuil 2002, 2004; Zurro et al. 2005; Hamon 2006, 2008, 2019; Rowan and Smith 2008; Verbaas and Van Gijn 2008; Delgado-Raack et al. 2008, 2009; Graefe et al. 2009; Bofill et al. 2013; Watts 2014; Dubreuil et al. 2015; Di Bella et al. 2018; Hayes et al. 2018; Alonso

2019; etc.). Within the context of early agricultural societies, grinding tools have also been discussed alongside evidence from physical anthropology, given the connection generally observed between milling of foodstuffs and changes in the material conditions of existence that have biological implications (Molleson et al. 1994; Eshed et al. 2006; Soltysiak 2011; Irvine et al. 2014; Sladek et al. 2016; etc.).

Traditionally, grinding tool assemblages have had a very limited role in the study of Iberian Late Prehistoric material culture and technology. Again, however, in the last 20 years, the situation has changed dramatically, with a growing number of papers being published, especially for the Bronze Age (Risch 1998, 2002; Menasanch et al. 2002; Delgado-Raack 2013; Delgado-Raack and Risch 2016; López Plaza et al. 2016) and Iron Age (Guerin 1999; Alonso 2002; Ceprián del Castillo and Luna Collantes 2006; Quesada Sanz et al. 2014; Teira Brión and Amado Rodríguez 2014; Roldán Díaz and Adroher Auroux 2017; Kavanagh de Prado et al. 2019). There is still a scarcity of such studies for the Late Neolithic and Copper Age, despite the generally widespread presence of grinding tools in both periods (but see Risch 2008; Menasanch et al. 2002; Portillo and Albert 2012; Valera et al. 2018).

There are various reasons why Valencina offers a suitable case-study for examining the interpretative potential of grinding tools. Despite the fact that more than 130 excavations have been undertaken at the site (almost all of them of the ‘rescue archaeology’ kind), no systematic analysis of this category of material culture has ever been carried out. Recent discussions of Valencina have pointed out the surprisingly low number of grinding tools in excavation reports, especially when compared with other Late Neolithic, Copper Age and Early Bronze Age sites in southern Spain (García Sanjuán 2013, pp. 34–35; García Sanjuán et al. 2017, p. 250). Of course, this observation begs the question of whether the low number of published grinding tools is due to the dearth of good-quality excavation reports and post-excavation studies, or whether it derives from the intrinsic nature of the social practices taking place at the site. Solving this problem is all the more relevant insofar as grinding tools are crucial empirical indicators of the very nature of sites such as this. It is important to note that, as with other European mega-sites, there are alternative hypotheses to explain the vast spatial extent of the site and the remarkable scale of some of its monuments. They range from interpreting Valencina as a village permanently occupied by a substantial human contingent, to its being a locus for periodic gatherings of people living in the surrounding regions, or even a mixture (perhaps changing over time) of those two possibilities (see discussion in García Sanjuán and Murillo-Barroso 2013; García Sanjuán et al. 2017, 2018b). If Valencina was the residence of a significant stable community, then its artefactual record should be expected to show substantial numbers of grinding tools, as at other Late Prehistoric settlements across southern Iberia.

In the light of this, we present here the first ever study of Valencina's grinding technology. This study adopts a broad multi-disciplinary perspective that includes: petrological and geochemical characterisation of the raw materials; techno-morphological classification and the assemblage; functional study of the tools through use-wear analysis; and discussion of their contexts, in line with earlier studies that paved the way for this line of research in Late Prehistoric Iberia (Risch 2002; Delgado-Raack 2008). For practical reasons – not least the huge quantity of excavated material from Valencina,most of which remains unstudied – our research is based on a sample that includes seven assemblages of finds from as many excavations (see description in the next section). This research has two general aims. The first concerns lithic technology as such, including procurement of raw materials, their transformation into tools, and the function and use-life of these tools. The second aim is to understand what this empirical evidence can tell us about what the tools were used for, including productive and economic processes, and their eventual discard and deposition. These two aims have the potential to provide answers about the social practices that led to the formation of mega-sites.

2. Material Sampled

2.a. Context and Quantification

The vast extent of the finds inventory from excavations at Valencina made it imperative to establish a sampling strategy for this research. This strategy is based on two principal criteria. First, since it is known that the macrolithic materials from some excavations have been discarded on the basis of non-explicit criteria (a damaging practice that is regrettably still common in rescue excavations across Spain: Teira Brión and Amado Rodríguez 2014, p. 271), the collections to be studied must come from excavations based on a full-record recovery. Second, the spatial distribution of these excavations should be representative of the whole site, and not just a small portion of it. On this basis, seven excavations were selected: Calle Trabajadores nº 14–18, PP4-Montelirio, Instituto de Enseñanza Secundaria (IES), Ampliación IES, Calle García Lorca, Depósito del Agua and Pabellón Cubierto (Fig. 3). A short description of each of these sectors will be provided, including the available evidence on their chronology – a summary is presented in Table 1.

Calle Trabajadores 14–18: The excavation undertaken in 2008 on this plot of land, located in the northern half of the site and covering an area of 300 m^2, led to the discovery of 30 negative features of various sizes and depths, predominantly circular or sub-circular in plan (López Aldana and Pajuelo Pando 2013). There are currently 20 radiocarbon dates available for this sector, from structures #1, #77, #90 and #136 (all containing human remains). Bayesian modelling of these dates suggests that use of these features started between 2580 and 2465 cal BC 2σ), ending between 2470 and 2310 cal BC 2σ), with a likely time span of use of 1–245 years 2σ) (García Sanjuán et al. 2018, pp. 243–244). Their use is, therefore, 'late' in the history of the site – there are very few well-documented contexts dated later than 2400–2300 cal BC. The lithic finds of this excavation fill 48 crates (960 kg approximately), currently kept at the Valencina Municipal Museum. The large quantity of unworked tuff blocks is worth noting, some up to 80 cm in size, which is a raw material not documented previously in Valencina. According to the results of our study, this excavation yielded 78 grinding tools (with a combined total weight of 111.17 kg), which represented almost half (42.2 %) of the 185 items included in this study.

PP4-Montelirio: Between 2007 and 2008, a total of 18,878 m^2 (1.8 hectares) were excavated in this sector, located on the southeastern quadrant of the site, contiguous to the Montelirio tholos. In total, 134 Copper Age features were identified, 61 of them containing human remains. Morphologically, the vast majority of those 134 structures are pit-like features, although some are megalithic in nature (Mora Molina et al. 2013). Altogether, the evidence retrieved during the excavation amounts to 100 crates, currently kept in the Archaeological Museum of Seville, half of them with human remains, and the other half with artefacts. To date, several studies on the biological deposits and material culture of this sector, and especially those of Structure 10.042-10.049, have been published – see summaries in García Sanjuán et al. (2018a, 2019). There are 28 radiocarbon dates for this sector, of which eight have been published (García Sanjuán et al. 2018b, pp. 227–232); the other 20 are currently awaiting publication. These dates suggest the sector was in use for a period of 150–200 years between the 29th and 28th centuries cal BC. Our study has identified 19 grinding tools from PP4-Montelirio (10.3% of the total studied here) with a combined weight of 35.26 kg.

Instituto de Enseñanza Secundaria (IES): Excavations covering an area of 7650 m^2 carried out here between 2005 and 2006, roughly at the geographical centre of the site, led to the discovery of more than 150 negative features. Most of these features are pit-like (circular or subcircular in plan, with a maximum diameter of c. 1 m), although some, for example Structure #34, showed a more complex morphology and a larger size (Vargas Jiménez et al. 2010). These structures presented a variety of infills, including, in some cases, human remains. Structure #402 yielded evidence of ivory processing (Nocete Calvo et al. 2013). Up to 15 radiocarbon dates are available for IES, suggesting a period of use between the 30th and 27th centuries cal BC (García Sanjuán et al. 2018b, pp. 223–225). In total, the lithic material retrieved in this excavation amounts to ten crates, currently kept at the Valencina Municipal Museum. Our review of these finds has revealed 54 grinding items 29.2% of those studied here), with a combined weight of 43.62 kg.

Ampliación IES: Covering an area of 622 m^2, the excavations carried out in 2011 in this sector, neighbouring IES, yielded a series of features and finds, for which there are no published reports. In addition, no radiocarbon dates are available at present. Our review of the two crates of lithic material from this excavation, kept at the Valencina Municipal Museum, revealed 7 grinding items (3.8% of those studied here) with a combined weight of 6.58 kg.

Depósito de Agua: Excavations undertaken in 2003 at this sector also remain unpublished. Preliminary excavation reports mention a series of burial features and a negative feature interpreted as a ‘hut floor’ (Vargas Jiménez 2010, p. 3342). No radiocarbon dates are currently available. Our examination of two crates of lithic material kept at the Valencina Municipal Museum identified three grinding items (1.6% of those studied here) with a combined weight of 14.63 kg.

Calle García Lorca: The excavation carried out in 2009 over an area of 504 m^2 at García Lorca street, in Valencina de la Concepción, remains at present unpublished. No radiocarbon dates are available. Our study of the four crates of lithic material kept at the Valencina Municipal Museum led to the identification of 11 grinding tools (5.9 % of those included in this study) with a combined weight of 13.94 kg.

Pabellón Cubierto de Valencina: Between 2008 and 2009 an area of 1600 m^2 was excavated at the plot of land destined to host the new municipal sports centre at Valencina, leading to the discovery of several Copper Age and Iron Age features (Ortega Gordillo 2013). To the Copper Age were attributed 29 negative structures consisting mostly of small-sized circular pits between 0.45 and 1.80 m in depth. An exceptional larger structure (4 x 3.5 m), oval in plan with two post holes within, yielded a large quantity of material (465 bags of finds), including Bell Beaker pottery from the upper levels of the fill. No radiocarbon dates are available for this sector. Our study of 11 crates of lithic material led to the identification of 13 grinding items (7.0 % of the sample included in this study) with a combined weight of 10.92 kg.

Taken together, the seven excavations briefly described above amounted to a total excavated area of 29,554 m^2, which represents approximately 0.7% of Valencina’s spatial extent (estimated at 450 hectares). These seven excavations yielded 79 crates of lithic material, with a combined weight of approximately 1580 kg. We reviewed this material, crate by crate, item by item. The final count of grinding tools stands at 185 items, with a total weight of 236.14 kg (Fig. 4 and online Suplemmentary Data). This is the empirical basis for our study.

In our sample there is no apparent positive correlation between excavation area and number of grinding tools. If anything, the opposite seems to be true. The largest excavated sector, PP4-Montelirio (just under two hectares) yielded only 19 grinding items (10.3% of the total for this study), whereas the smallest excavation, that of Calle Trabajadores nº 14–18 (330 m$^{2)}$, yielded the highest count of all, with 78 items (42.2% of our sample). In fact, two of the sectors, namely Calle Trabajadores nº 14–18 and IES, supplied 71% of all the items we identified. This suggests a non-uniform spatial distribution across the site. Although the small fraction of the site area represented in our study (0.7%) argues against making any categorical statements, the spatial distribution of grinding tools across the site appears to be irregular, with concentrations in specific sectors relating to the use they had throughout the long biography of the site. For the time being, however, this remains a hypothesis.

It is important to keep in mind that the seven sectors of Valencina studied in this paper have different chronologies and, therefore, the material culture represented might be the product of different social and cultural circumstances. Only three of the sectors have a reliable radiocarbon chronology. PP4-Montelirio and IES (and possibly Ampliación del IES, which is adjacent to the latter) have an ‘early’ (pre-Beaker) chronology, between the 30th and 27th centuries cal BC. On the other hand, Calle Trabajadores14–18 has a ‘late’ chronology, between the 27th and 25th centuries cal BC, presenting a large amount of Beaker pottery, which was also identified at Pabellón Cubierto. In principle, at least in terms of the sheer number of grinding objects, there seem to exist no significant differences between ‘early’ sectors (IES, Ampliación IES and PP4-Montelirio), with 80 items, and ‘late’ sectors (Calle Trabajadores 14–18 and Pabellón Cubierto), with 91 items.

2.b. Integrity vs Fragmentation

Preliminary observation by the naked eye revealed a high level of fragmentation among the grinding tools under study; this was especially perceptible in the grinding slabs (see examples in Fig.s 5, 6, 7 and 8). To assess the degree of integrity (or, to put conversely, fragmentation) of this collection of tools, each item was allocated to one of four categories according to the percentage of the original tool it is estimated to represent: 100%, 50%, 75%, 25%, <25% (Fig. 9). The results (Fig.s 10 and 11) show that 58% of items in our sample constitute less than 25% of the original artefact, whereas a staggering 90% represent less than 50% of the original object. Only 6.6% of the items are complete; overwhelmingly, these are active or hand-held tools (hammers, grinders and hammers/grinders). Passive or placed tools, such as grinding slabs and sharpener/polishers, appear highly fragmented; only 8 of 112 querns are complete, and these come in all cases from surface finds and structures of uncertain type, whereas 87 (77%) are fragments that constitute 25% or less of the original object. A striking feature of this assemblage of materials is therefore its high degree of fragmentation.

The break-down by sector shows that the rates of integrity/fragmentation are very similar across the site (Fig. 11). The fact that a high rate of fragmentation is common to all sectors regardless of their spatial location and chronology suggests that all objects included in this sample experienced similar patterns of breakage, fragmentation and discard.

The high degree of fragmentation radically separates the Valencina grinding assemblage from the best-known collections in southern Iberia, from Early Bronze Age Argaric settlements like Peñalosa or Fuente Álamo, for which large quantities (in the hundreds) of complete querns (grinding slabs) have been found (Risch 1998, 2002). The low degree of integrity observed at Valencina must be explained either by the practices of deliberate fragmentation common among communities of the 4th and 3rd millennia cal BC throughout Europe (Chapman 1999; Chapman and Gaydarska 2007; Valera 2019), which in some cases have been noted to affect grinding tools in particular (Tsoraki 2007; Graefe et al. 2009, p. 32); by the recycling of spent or broken tools in order to prolong their use-life (Schiffer and Skibo 1987) as ‘redesigned tools’ (Adams 2002); or else by a combination of the two factors. This problem is discussed further in the conclusions section of this paper.

3. **Lithological Characterisation and Provenance of Raw Materials**

One of the aims of this study is to characterise the stones used to produce grinding tools and to establish their provenance. Previous studies of lithic resources at Valencina have revealed a wealth of procurement patterns and a diversity of provenances, both for the building materials used in megalithic monuments (Cáceres Puro et al. 2014; Borja Barrera and Borja Barrera 2016) and for knapped lithic industries (Morgado Rodríguez et al. 2016; García

Sanjuán et al. 2016). Until now, however, no attempt has been made study the stones sources used for grinding tools.

Following previous experience with materials from other sites, the methodology used here is based on analysis through petrology and optical microscopy and comparison with reference databases (Lozano Rodríguez et al. 2016, 2017, 2018). Samples for petrographic thin section analysis were extracted from already fractured or deteriorated surfaces in order to minimise the visual impact on the item. Given the hardness of the artefacts under study, the extraction was carried out with a Hinhell sb 401/1, 230v, 50Hz, 350W monophasic desk drilling machine provided with an 8-mm diameter water-cooled hollow drill and Widia 7 diamond point. The cores thus obtained were used to produce the thin sections. Petrographic analysis of the thin sections was undertaken with an Olympus BHT optical microscope. In order to establish the lithology of each sample the mineralogy, texture, structure and other petrological characteristics were considered. In total, 12 thin sections were extracted (Fig. 12).

The result of this analysis shows that the grinding tool assemblages from Valencina were manufactured using a wide array of rock types, all sharing a common denominator: their hardness and abrasive character (Table 2).

A first group of materials are those used to manufacture tools classified as ‘passive’ (see description below), basically querns: granite, sandstone and micro-conglomerate. Granite was preferred to make querns (N=48; 39.7%). Because of its crystalline texture (sometimes with large crystals) and components (quartz and feldspar), granite is very hard and has high abrasive capacity. In general, the larger the granite grains, the lower the hardness and the more friable the material is. In our sample the predominant grain size is medium (Fig. 12: G and H).

Another major group of tools (N=23; 19.8%) was manufactured on sandstones, which also have quartz as their main element. The sandstones documented in this sample are fine-grained and cemented, with grain-supported texture providing a high degree of compaction. The third group of passive tools for grinding (querns) were manufactured on micro-conglomerate, which in this case presents homogeneous, small-sized and angular grains, predominantly in quartz.

A second major group of tools, classified as 'active' (see description below), were manufactured on rocks such as quartzite and amphibolite. Pebbles of quartzite, a rock with a high degree of hardness resulting from the recrystallization of quartz grains in metamorphic proceses, are widely available in the neighbouring fluvial terraces of the lower Guadalquivir valley. Up to 22 items in quartzite, used for hammering and grinding, are documented in our sample (N=22; 34.4%). Amphibolite, a metamorphic rock of intermediate gradient facies with granoblastic and/or porphyroblastic texture presents an even higher degree of hardness than quartzite, and was also used for hammering and grinding tools (N=15; 20.4%). Absent from the immediate vicinity of Valencina, amphibolite has been cited in previous studies of lithic procurement in Iberia (Read et al. 1997; Lillios 1997; Valera 2009), and central Europe (Nowak 2008).

Altogether, the results of our study reveal a catchment area for grinding-tool raw material between 10 and 30 km from the site, particularly within the Sudportuguese Zone (Fig. 1 and 2). At a distance of 10 km from Valencina quartzites, quartzitic sandstones, conglomerates and slates are available (group of slates and quartzites in the Pyrite Belt). Volcanic or pyroclastic rocks, basically dacites, are also available in the Volcanic-Sedimentary complex of the Pyrite Belt, some 20 km distant from Valencina. Granites are available at a distance of 15 km, whereas graywackes can be obtained some 30 km away from the site. Quartzite pebbles are widely available at shorter distances, within the fluvial terraces of the Guadalquivir river. In general, this short-to-medium range of catchment for grinding tools matches closely what is known for the construction materials of large tholos-type megaliths such as La Pastora, Montelirio or Matarrubilla, which include limestone, slate, granite and less common materials such as talc (Cáceres Puro et al. 2014, 2019; Borja Barrera and Borja Barrera 2016). Amphibolite, on the other hand, would have involved longer transport distances, since the nearest source location, the Bejar-Acebuches formation, is located some 50 km away from Valencina (Fig. 1).

The presence of prestige artefacts made of ivory (García Sanjuán et al. 2013; Nocete Calvo et al. 2013), rock crystal (Morgado Rodríguez et al. 2016), amber (Murillo-Barroso 2016) or siliceous rocks such as flint and mylonite (García Sanjuán et al. 2016) and the use of cinnabar (Rogerio-Candelera et al. 2013), reveal beyond any doubt that obtaining raw materials from long distances was not a problem for the communities that inhabited or frequented Valencina. Hard rocks like those used for the grinding tools studied here, such as granite, sandstones, micro-conglomerate or quartzite, were easily procured at much closer locations and therefore would not have been invested with the 'power' of the exotic and the distant.

4. Morphological Analysis

The description of the morphometric and morphotechnical characteristics of the tools studied here is based on both qualitative and quantitative variables. Measurements were taken with a caliper for smaller items, whereas for the larger ones a ruler attached to a fixed support was used. Error margins are of 0.5 mm for the caliper and 1 mm for the ruler. Weights were recorded with two weighing machines: one with a range from 1 g to 5 kg, and another for weights above 5 kilos and up to 150 kilos. For passive elements four measurements were taken: longitudinal axis (length), transverse axis (width), maximum height (thickness) and weight. Qualitative variables included active surface type and number of active surfaces (as well as lithology). For active elements, four measurements were taken: length, width, thickness and weight (Fig. 9). As qualitative variables, we considered the number of active surfaces and type of natural blank as well as lithology. Every item has been examined both macroscopically and microscopically for vestiges of use wear, recycling and thermal alterations – see discussion below.

Our morphological analysis is based on two main theoretical approaches: the *chaîne opératoire* for production, and object biography for history of use. First proposed for knapped flint artefacts (e.g., Leroi-Gourhan 1964; Pelegrin et al. 1988, Edmonds 1990; Karlin et al. 1991) the *chaîne opératoire* approach has been defined as the set of connected actions necessary to produce a tool, from the collection of the raw material to its final discard, including all phases of manufacture, use, repair and reuse, and has been successfully applied to a much wider range of technologies. The object biography approach complements the *chaîne opératoire* by shifting the emphasis to the involvement of the artefact in the social life and human psychology it was made to be part of (e.g., Kopytoff 1986; Appadurai 1986). Thus, objects are not necessarily just technologies, but also active agents of social life, attached to individuals and corporate groups and with biographies (birth, life and death) imbued with cultural significance and social values and connected to worldviews.

Based on morphology and use-wear traces (as explained below), the sample of tools involved in grinding technology has been grouped in two major categories according to the primary role they played in the productive process: passive (querns and sharpener/polishers) and active (grinders, hammers and hammer/grinders). These two categories are not considered mutually exclusive, since both groups of tools were complementary in the productive process as elements involved in or connected with the manufacture and maintenance of grinding tools. The distribution of our sample according to these categories is shown in Fig. 13. The breakdown of these categories by sectors (Fig. 14), suggests this pattern is consistent throughout the site.

4.1. Passive Elements

Querns or grinding slabs: This is the largest group in the sample, with 112 items (60.5% of the total studied here). The high fragmentation of the material has made it possible to measure entire examples only in thirteen cases. According to their size (length and breadth), three subgroups can be defined according to size: the first includes examples of 20–25 cm in length by 15–20 mm in breadth (small querns); the second includes items of 30–40 cm x 20–27.5 cm (intermediate); and the third includes items of 50–55 cm x 30–35 (large). In general, there is more variability in length than in breadth, whereas it is difficult to assess variability in thickness, as this variable can be greatly influenced by the use time and number of active surfaces on the item. Geometrically, these tools tend to a sub-rectangular shape, the most repeated shape being oblong (Fig. 15 and 16). In terms of active surfaces, 104 items (85.9%) present just one (Fig. 15:1 and 15:3), while 17 (14%) have two (Fig. 15:2). Two kinds of active surfaces have been identified: flat (Fig. 15), with 92 occurrences (76%); and concave (Fig. 16), with 26 examples (22.3%) (Table 2). The rocks these tools were made on are basically granite, arcose and, to a lesser extent, microconglomerate.

Sharpeners/polishers: This group includes 9 tools (4.8% of the total) intended for sharpening or polishing other tools. Their highly fragmented state makes a full morphometric characterisation impossible. The fragmented items available are square or quadrangular in shape, just over 10 cm in length and 8 cm in width (Fig. 16:3 and 4). Flat active surfaces (six in total) seem to prevail over the concave ones (three), whereas there are six items with one active surface and three with two. The materials used to manufacture these tools are basically fine-grained sandstones.

4.2 Active Elements

Grinders: These tools (comprising 24 items, or 12.9% of the total studied here) were used in conjunction with grinding slabs in milling tasks and therefore only present traces of abrasion. Their average size is 10 cm in length, 10 cm in width and between 4 and 7 cm in thickness, with weights between 700 and 1300 g. Morphologically they are sub-rectangular or oblong (Fig.s 17:1 and 17:2). Sixteen of these items have only one active surface, while eight have two; active surfaces are flat in five instances and convex in just one case. Lithologically they are usually made of granite, followed by microconglomerate and, in one case, dacite.

Hammers/grinders: This group of 16 items (8.6% of the total) includes tools used for grinding in conjunction with querns; in addition to the abrasion traces typical of grinding action, they also present signs of percussion. These tools present mostly circular or oblong shapes and have sizes of between 7 and 11 cm in length, 6 and 9 cm in width and 3 and 6 cm in thickness (Fig.s 17:3 and 17:4). All active surfaces are convex. A large majority of these tools were made on quartzite pebbles (56.2%), followed by granite (12.5%) and, to a lesser extent, rocks with granoblastic and/or porphyroblastic texture, such as amphibolites and ophite.

Hammers: The most numerous group of active tools, with 24 items (12.9% of the total), is hammers, characterised by their percussion traces. With subrectangular, oblong and sometimes circular shape (Fig. 17:5), these tools are similar in size to those in the group of hammers/grinders: 7–10 cm in length, 4–9 cm in width, and 3–7 cm in thickness, with weights ranging from 200 to 1000 g. Lithologically they are compact and hard metamorphic rocks such as quartzite and quartz (60%) and amphibolites and diabases (40%).

5. Functional Analysis

In this section we describe the results of the use-wear analysis in terms of the actions and activities the tools were used for, including thermal alterations and recycling to prolong their use-life. Use-wear analysis was undertaken with the help of images obtained with a Nikon D5000 camera with an 18–55 mm VR NIKKOR AF-S DX lens and with a Leica EZ4 HD stereo microscope with 8x-to-050x zooming capability coupled with a Canon EOS 1200D photographic camera provided with EF 100mm f/2.8 USM macro lens. Whenever possible the conventional terminology for the study of active surfaces (see Adams et al. 2009; Dubreuil et al. 2015) has been followed. Use-wear traces on active surfaces offer two types of evidence: first, the direction and kinetics of the work applied, and second the kind of use the tool was given. Previous lithological characterisation of the tools (mineralogical composition, texture) is essential in order to understand use-wear traces (Adams et al. 2009; Delgado-Raak et al. 2008; Dubreuil et al. 2015). Inferences concerning the activities represented by the use-wear traces have been made of the basis of conventional analogies drawn from ethnoarchaeology and experimental work (Adams 1989; Adams et al. 2009; Risch 2002, pp. 111–127; Menasanch et al. 2002; Dubreuil 2004; Delgado-Raak 2008, pp. 292–347; Hamon 2008).

5.1. Active Surfaces

The granite used to make grinding slabs shows medium grain, and high quantities of highly compact quartz. Friction and abrasion led to flat-regular active surfaces as well as levelling of the quartz grains on these tools. Intense shiny polish has also been recorded in a number of them (Fig. 18: 1 and 1A). There are two types of topographies in the active surfaces of querns made of granite or sandstone: flat-regular with levelling of the crystals, and sinuous-regular, with rounding of the crystals. In querns made of micro-conglomerates, active surfaces display a sinuous-regular topography, with both levelling and loss of grains (Fig. 18: 2 and 2B).

As mentioned above, quartzite pebbles were selected to make active tools used as grinders and hammers. Two types of use-wear traces of hammering have been found. The first is characterised by grain loss and rugged flat active surfaces, suggesting percussion on soft materials (Fig. 18: 3C), which must have included organic elements such as animal bones, seeds, and fruits. In the tools we have termed hammers/grinders, these traces appear combined with abrasion. The second type includes grain loss and rugged irregular active surfaces, with frequent accidental flaking, and suggests percussion on hard materials (Fig. 18:4), for example in the context of lithic knapping, crushing of cupriferous minerals, pecking or maintenance of active surfaces on the grinding slabs. These marks appear in hammers with no evidence of abrasion, and in hammers/grinders that also show accidental flaking (Fig. 17:3). The active surfaces of hammers made in amphibolite are rugged and show fractured crystals; occasionally, the evidence of percussion appears in combination with traces of abrasion such as grain levelling and parallel grooves.

5.2 Activities

The direction of use-wear traces on both passive and active elements suggests two types of operation: on flat and on concave surfaces (Fig. 19 and 20). From a technical point of view, the passive and active tools (grinding slabs and grinders) must present matching morphologies. The morphological analysis of grinding tools and their active surfaces provide the basis for a quantification of the frequency of each combination (Table 3). Flat active surfaces appear more frequently (76%) than concave or convex surfaces (22.3%).

As expected, querns and grinders display similar use-wear patterns, including grain levelling and totally regular surfaces (Fig. 19:1, 2 and 3), as well as intense polish with shiny surfaces (Fig. 20: 1 and 2). In grinding tools, polished areas appear evenly distributed across the active surface. The morphology and wear of grinders, with regular surfaces and evenly distributed polish, do not suggest leather or skin tanning, which usually produces rugged active surfaces with grain rounding and shiny polish concentrated on the grains and not across the entire surface (Adams 1988; Dubreuil and Grosman 2009). Tools classified as hammers/grinders present evidence of percussion on soft materials over the outer edges (Fig. 20:1).

Querns with flat active surfaces present two patterns of use-wear (Fig. 19). The first pattern relates to the active surfaces of flat grinders. They show regular flat topographies with levelling of grains and pits as a result of maintenance pecking (Fig. 19:1, 2 and 3). As a result of friction with the stuff being ground, a rounding appears on the edges of the pits (Fig. 19:3). This kind of wear appears on granite (Fig. 19:1 and 2) and other rocks such as calcarenite (Fig. 19:3). The second use-wear pattern is not connected with the use of a stone. In this case the topography is sinuous and regular and grains appear rounded (Fig. 19:4 and 5). Pits resulting from maintenance pecking appear in the entire active surface, showing smoothing caused by the stuff bring ground on it. This pattern must be connected with the use of a non-lithic, possibly wooden mano. Wood can wear softer materials and even round harder stones, such as quartz crystals; in fact, this pattern of wear appears on granites and sandstones. Both wear patterns detected on querns with flat active surfaces must be understood in connection with milling of cereals, as deduced by comparison with the results of experimental studies (Menasanch et al. 2002; Risch 2002; Dubreuil 2002; Zurro et al. 2005; Hamon 2008; Delgado-Raack 2008; Verbaas and Van Gjin 2008; Hamon and Plisson 2009; Bofil et al. 2013).

Querns with concave active surfaces hardly show any pits derived from maintenance pecking, whereas such pits do appear in all examples of flat-surfaced querns. The topographic irregularities caused by the maintenance pecking are important for the milling of cereals and therefore querns without evidence of such maintenance must have been used to mill not cereals but other kind of organic materials, possibly foodstuffs – acorns would be a primary candidate, as shown by other kinds of evidence (see discussion below). Polished and shiny surfaces in tools associated with grinding may have been caused by tribochemical process involving the friction between two lithic objects and the stuff being ground betwenn them. In querns with concave active surfaces some kind of green and fresh vegetable element was first threshed and then ground. The concave shape of the querns would have helped the process of grinding a stuff into a paste or even a liquid. The evidence does not rule out categorically the possibility that concave querns were used to grind cereals, but topographically the active surfaces do not seem as suitable for this foodstuff as those of flat querns.

In summary, according to the evidence presented above, there is no direct correspondence between the number of querns and grinders with flat active surfaces: against a total number of 92 querns with flat active surfaces there are only 22 grinders that may have been used with them. For concave-convex surfaces there is a better match with the number of querns and grinders. Ethnography suggests that manos normally outnumber querns (Horsfall 1987; Holter y Schön 1988; Gronenborn 1994; Bartlett 1933). The use of wooden manos could explain the relatively low number of gridstones with flat active surfaces and sinuous-regular use-wear pattern in our sample. Experiments have proved that grinders made of hard wood are as efficient as stone ones, or perhaps even more efficient, as they generate less wear on the surfaces of the querns and incorporate fewer residual particles in the flours and brans being produced (Risch 2002, pp.112–129; Delgado-Raack 2008, pp. 292–347). Thus, the two use-wear patterns on flat surfaces that we have defined would be associated with the milling of cereals, but using stone and wooden grinders respectively. This has already been suggested for Late Neolithic (Aranda Jiménez et al. 2012, p. 63), Copper Age (Risch 2008) and Early Bronze Age sites in southern Iberia.

The tools we have classified as sharpeners show abrasion use-wear with flat and regular topographies, grain levelling and parallel grooves on the active surfaces. Considering their size, shape and raw material, these tools must have been involved in the production and maintenance of polished lithic tools with sharp edges.

Finally, hammers, the most frequent tool among active elements, show use-wear connected with the manufacture and maintenance of grinding tools. It is not possible to rule out the use of these hammers in the crushing of mineral resources, but the absence of mortars and the distribution of the hammering areas makes this use unlikely.

Altogether, from a functional point of view the grinding technology found at Valencina seems to have served mainly for the processing of vegetable materials, especially grinding of cereals, but also includes tools used in the manufacture and maintenance of the grinding tools. In general, this can be interpreted in connection with the processing of foodstuffs within the context of farming communities.

5.3. Thermal Alterations

The study of the surfaces reveals that thermal alterations are quite prevalent in our sample of Valencina's grinding tools. Overall, signs of thermal stress affect 62% of all items and consistently appear with a similar frequency in all seven sectors of the site studied here (Fig. 21). These marks vary depending on the rock type. In tools made of sandstone, calcarenite and micro-congolmerates quartz grains show rubefaction resulting from exposure to temperatures above 200º C, as well as oxidation of iron particles, which results from tempratures above 1100 ppm (Purdy and Brooks 1971). The surfaces of tools made in granites and quartzites display fissures or cracks, whereas surfaces of those made in other stones display various nuances of color, including red, orange and black. In some materials, sudden temperature changes causing thermal shock result in cracks and even spontaneous flaking.

The presence of examples in which the rubefaction covers the entire surface of the tool, in both fragmented and recycled items, suggests that exposure to fire took place after the items were discarded. Instances of thermally-altered macrolithic tools have been cited at other sites of the 4th and 3rd millennia cal BC in southern Spain (Aranda Jiménez et al. 2012, p. 83; García González et al. 2014).

5.4. Reuse and Recycling

Our morphological and use-wear analysis of macrolithic tools reveals widespread reuse and recycling, which helps interpret the use-life and biography of some artefacts.

Fragments of querns were re-used as grinders, possibly because they were too old and worn-out (Fig. 22:2). These fragments generally represent one quarter of the original quern, the edges having been rounded to make them more ergonomic. Hammers/grinders also appear to have been reused as heavy-duty hammers. Accidental flaking causing sharper areas on the outer edges made hammers/grinders less suitable for the crushing and grinding tasks they were originally intended for, and better suited to more straightforward hammering tasks (Fig. 17:3 and 4). The recycling of hand axes and adzes has also been documented (Fig. 22:1). Generally used for wood cutting and carpentry, these tools usually fractured through the medial area due to repeated impacts. Since they were originally manufactured on hard rocks, once broken they were reused as hammers (Fig. 22:1A). The frequency of this reuse must be higher than observed, but the extensive use of hammers has prevented us from defining the recycling of some items.

Quantification of tool discard helps to assess the ‘use-rate’ of the artefacts studied here. Final discard occurs when a tool is no longer efficient in performing the task for which it was designed, unless other cultural or ideological factors intervene (for example, use as grave goods or offerings in votive deposits).

Most hammers/grinders were discarded when the working surfaces of the outer edges were too worn, or the abrading surface became too small due to accidental flaking (Fig. 17:3 and 4). Hammers were probably the longest-lasting tools, as no specific shape was required for them to perform their task. The hammers studied here, however, were used for maintenance pecking of the abrading surfaces of the querns, which means they must have been pointed in order to create micro-pits on the quern surfaces. The rounding of the active parts through wear suggests that they were used for as long as possible (Fig. 17:5). Ethnographic evidence shows that passive elements reach the end of their effective life when they fracture – unless they are broken deliberately for votive deposits or deposition in tombs (Adams 2008). Fractures must be connected with the maintenance pecking of active surfaces. In general, the presence of thinned-out querns suggests intense use (Fig. 22:3). In this case all of the querns were thinned-out to such an extent that their potential use-life appeared exhausted; a significant number of them (17) were provided with two active surfaces.

Overall, the evidence above suggests that grinding tools were intensively used, and reused, to the the end of their use-life, before being discarded.

6. Manufacturing Grinding Tools

The combined results of the lithological, morphological and functional analysis show that our sample of grinding tools from the Valencina Copper Age mega-site comprises fully finished tools, which were mostly used to the end of their effective use-life and in many cases reused. This situation makes it difficult – although not impossible – to identify the processes by which these tools were originally manufactured.

As mentioned above, most querns were made on granite and sandstone blocks. However, there is one example, found in sector Calle Trabajadores 14–13, that was manufactured in bioclastic calcirrudite and never used. Because it was never used, this item provides special evidence as to how querns were manufactured (Fig. 23:1). The reverse of the tool shows various extractions resulting from the flaking applied to obtain a convex shape (Fig. 23:1B). On the outer edges of its lower face there are marks of repeated impacts made to configure the desired oblong shape. These marks suggest successive and violent impacts aimed at rounding the sharper parts of the original (natural) stone block, and match those obtained in experiments (Fig. 23:C and E). Pecking or bush-hammering (Morgado Rodríguez and Martínez-Sevilla 2013) were then used to achieve a sinuous-regular active surface with several pits of varying depths (Fig. 23: D). All other grinding tools show knapping of the outer edges (Fig. 23:2A), but most show a natural surface (Fig. 23:2B). The reverses of querns were barely altered during the manufacturing process, usually keeping the natural surface of the original stone block. It is interesting to note that an unprocessed (unworked) quern roughout made of plutonic granite was identified in sector Calle Trabajadores 14–13 (Fig. 23:3).

On this evidence, the *chaîne opératoire* required to produce querns would appear to have involved the following steps:

1. Choice of the natural stone block. In the case of detritic sedimentary rocks, pebbles were selected and then cut to produce a flat surface; in the case of granites, blocks or slabs with a suitable natural shape were selected.
2. External knapping: the outer edges of the natural block were trimmed through direct knapping with a hard hammer. This stage was omitted in many cases as the natural block already had the desired form.
3. Configuration of the active surface: the grinding surface was formed through intense pecking or bush-hammering, which created a rugged surface capable of generating the necessary abrasion effect.
4. Maintenance of querns was achieved through active pecking or bush-hammering of the grinding surfaces once they became dull. Eventually, this maintenance through pecking would lead to excessive thinning of the tools, which at some point would break up accidentally. In the sample studied here we have documented granite querns that perhaps fractured during the maintenance pecking process, as suggested by the fact that maintenance pits overlap traces of grinding (Fig. 18:1). Analogous evidence has been recorded on querns made of sandstone and other sedimentary detritic rocks.

In the case of *active tools*, almost no technological processing for their production has been recognised. Two types of original blank are identified: those from unmodified natural quartzite pebbles, and those from the recycling of other tools. Grinders mostly appear to come from the recycling of fragments of spent querns, which were then adapted by a slight regularisation through hammering of the sharper edges (Fig. 17:2). Hammers/grinders were made from unmodified pebbles – which eventually, however, would show use-wear (Fig. 17:3 and 4). Hammers were also made from pebbles or recycled fragments of cutting tools such as hand axes or adzes. No evidence of maintenance pecking has been identified in active tools, although hammers, especially those with protruding edges and points, would have been used for the maintenance of querns.

The *chaîne opératoire* for the production and maintenance of grinding tools is similar to that noted at other southern Iberian sites of Late Neolithic (Aranda Jiménez et al. 2012, p. 60), Copper Age (Risch 2008) or Early Bronze Age (Risch 1995; Delgado-Raack 2008; Delgado-Raack and Risch 2016) date. Similarly, the use of pebbles as grinders is common at other Copper Age sites (Risch 2008, p. 26).

7. Context

In order to contextualize the assemblage described above, a subsample was selected, including only those objects for which secure contextual information is available. Surface finds, or items from poorly-undertood stratigraphic units and structures were excluded from this analysis. The resulting subsample amounts to 111 items, including 58 from Calle Trabajadores 14–18, 35 from IES, 9 from Pabellón Cubierto, 6 from Ampliación IES and 3 from PP4-Montelirio (Supplementary Table 1).

The large majority of macrolithic tools in this subsample (106 items, or 95.1%) were found in simple negative features. Of those, 77 (69%) come from basins (shallow negative features with a maximum diameter of c. 1–2 m and depth of 30–50 cm) and 29 (26.1%) from pits (negative features of about 1 m in breadth and depth). Pits and basins are pervasive in the archaeological record of the 4th and 3rd millennia cal BC throughout Iberia, and there is no unanimously accepted functional interpretation for these features, which have been variously interpreted as 'silos', 'refuse dumps', 'hut floors' or 'structured depositions' – see discussion in Márquez Romero and Jiménez Jáimez 2010.

Three items were found in ditches. One of them, a quartzarenite quern fragment (less than 25% of the original object) found next to a complete ceramic vessel, comes from UE 322 of the PP4-Montelirio sector, which is one of the ditches that form Structure 10.024, a ditched enclosure with a maximum diameter of c. 17 m and a possible entrance on its southern side. Inside this enclosure, and also cutting the ditch, several pits (mostly circular in plan) were found. These features yielded a large quantity of faunal remains, which amount to 95% of those found in the entire PP4-Montelirio sector (Liesau et al. 2014, p. 77), as well as a large quantity of pottery (Mora Molina et al. 2013, p. 274). One of the pits inside Structure 10.024 (UE 547) also yielded a fragment of a sharpener/polisher in quartzarenite included in this study. It is important to note that, although segments of large ditches have been found in other sectors, Structure 10.024 remains for the present the only ditched enclosure confirmed through excavation in the whole of Valencina.

At IES, two items – a small fragment of a quartzarenite quern and a sharpener/polisher of the same material – were found in UE 34, a complex polylobate negative structure of larger size than the pits and basins. This structure was 7.45 m long (N–S axis) and 6.22 m wide. The bedrock surface forming its floor was marked by differences in levels, thus showing a series of separate areas accessed by ramps and steps, with a large posthole at the centre. The artefacts recovered from the structure included fragments of slag, tuyères and some copper tools, alongside pottery.

Approximately one-third of the items included in this subsample (35 objects, or 31.5%) were found in features that also contained human remains. Twenty-one of them, however, come from a single feature: Structure UE 136 at Calle Trabajadores, a feature in which a human skull and mandible were found alongside 14 quern fragments, 4 hammers/grinders, 2 hammers and 1 grindstone. In addition to the human remains, Structure UE 136 contained charred material, burnt clay, faunal remains and a small number of ceramic fragments, as well as what appeared to be a double ring of small and medium-sized stones. No association between human remains and grinding tools was observed in any of the other six sectors, and notably not at PP4-Montelirio, where a large number of burial structures were found. This prevents a more detailed examination of the possible association between macrolithic tools and biological sex, such as that discussed at Neolithic sites in northeastern Iberia such as Bòbila Madurell and Can Gambú (Allièse 2016, pp. 253–54). Despite the lack of association between burials and macrolithic tools in six of the seven sectors of Valencina studied here, it should nonetheless be noted that the single structure with the largest assemblage of macrolithic tools so far identified at Valencina (21 items) does include human remains and evidence of burning.

The breakdown by function of the subsample of well-contextualised items shows that the large majority are quern fragments (65 items, or 58,5% of the subsample), followed by grinders (17), hammers/grinders (13), hammers (9), sharpeners/polishers (6) and a single polished stone axe. In terms of integrity/fragmentation, this material presents a striking pattern whereby not only is there no single example of a complete quern, but 57 out of the 65 quern fragments (87%) represent less than 25% of the original object, while the other 13% represent less than 50% of the original piece. The total absence of complete querns and the extremely high degree of fragmentation suggest that there was a defined pattern of deposition for this type of object which ensured that only fragments which had been recycled into a different kind of object (normally an active one) were discarded or deposited.

Other types of objects present a much higher degree of integrity. Up to 47% of grinders, 61.5% of hammer/grinders and 89% of hammers are complete. Therefore, the high degree of fragmentation of querns seems to represent a well-defined cultural pattern. As is discussed below, this pattern may indicate the high economic, social and symbolic value of this particular type of object, as proposed by earlier studies (Tsoraki 2007; Graefe et al. 2009; Watts 2014a; 2014b). The argument for a significant symbolic dimension in the practices that led to the deposition of querns appears to be supported by the fact that a large proportion of them, specifically 79 out of 111 in this subsample (71.1%), present evidence of thermoalteration.

8. Conclusions

This is the first ever analysis of grinding technology at the Valencina Copper Age mega-site. Our approach, based on a multi-disciplinary methodology that includes geological characterisation, morphological analysis, use-wear analysis and contextual analysis, leads to a series of significant conclusions. First, it is important to note that our results are consistent across the seven assemblages included in the study (totalling 185 items) in terms of rates of integrity/fragmentation, frequency of morphological types, functional configuration and thermal alteration. This suggests that this sample can be assumed to be fairly representative of the roles played by grinding tools in different parts of the site, and throughout its entire occupation history, which spans almost a thousand years. Second, our results lead to a number of conclusions about raw material supply, craft specialisation, and the function, context and significance of macrolithic technology in 3rd millennium BC Iberia.

The data presented above show that raw materials for the manufacture of grinding tools were mostly procured locally. Hard rocks are widely available in the vicinity of Valencina: quartzites, quartzitic sandstones, conglomerates and slates can be found within a 10 km radius, especially in the Sierra Morena and Andévalo regions to the north and west, and quartzite pebbles are readily available in the fluvial terraces of the Guadalquivir river at even shorter distances. Granite can be found within 15 km and volcanic rocks such as dacites within 20 km. Only amphibolites would have had to be brought from medium distances, above 50 km. The predominantly local character of these lithic resources is consistent with what is known about the building materials used in large megalithic monuments such as La Pastora and Montelirio, while at the same time it provides an interesting counterpoint to the extensive presence at Valencina of artefacts made of exotic materials transported over long or very long distances, such as flint, mylonite, rock crystal, ivory, ostrich eggshell, amber, variscite and cinnabar.

A striking feature of the grinding tools from Valencina is their extremely high degree of fragmentation. For up to 58% of the pieces studied here, the item under analysis represents less than 25% of the original artefact, while for a remarkable 90% it represents less than 50% of the original object. Only 6.6% of the 185 items included in our sample are complete. This is especially noticeable among the querns (or grinding slabs), of which there are only 8 intact examples, all of them either surface finds or coming from structures of uncertain character and chronology. If only artefacts from well-defined contexts are considered, the degree of fragmentation of the querns is even greater: this subsample indeed includes not a single whole quern, and furthermore 87% of the quern fragments represent less than 25% of the original object.

The extremely high degree of fragmentation sets the Valencina assemblage of grinding tools entirely apart from those of Argaric Early Bronze Age sites, in south-eastern Spain, where hundreds of complete querns, totalling several tonnes of lithic material, have been found (Risch 2002). Across Europe, other Neolithic sites also present highly fragmented assemblages of grinding tools. Such is the case, for example, at LBK and Late Neolithic settlements in France and Germany (e.g. Zimmermann 1988), or Vinça settlements in SE Europe (Vuckovic 2019). However, some LBK sites have also been found to present highly structured hoards of large-sized whole querns (Hamon 2019). How is the remarkable degree of fragmentation of the Valencina querns and, most importantly, the lack of whole querns to be explained?

Part of the answer may be that that many of the querns were recycled and re-used once broken. This alone, however, does not provide an adequate solution: at any given time, a number of whole querns must have been in use at Valencina. Why are those intact querns not represented in any of the seven assemblages studied here? Or, to put it another way, why did complete querns not enter the Valencina archaeological record? One possible answer might be that querns were not deliberately broken up before they were deposited (as the use-wear does not show any evidence of that), but that only objects already broken were selected for deposition. The contexts in which grinding tools were found becomes crucial for understanding the highly fragmented nature of this assemblage.

The *chaîne opératoire* and the level of expertise suggest that the production of grinding tools would not have required a high degree of technical specialisation. In terms of stone-working, the the tasks required to produce querns were comparatively unchallenging, which means the process must have been accessible to a wide range of people and was probably common knowledge. It is unlikely that the production of grinding tools was restricted to a small community of artisans. It is important to note, however, that groups of highly skilled craftworkers must have existed among the communities that inhabited and/or frequented Valencina, since there is ample evidence of far more technically challenging craft production, such as the long-barbed ultra-thin mylonite arrow heads, the beaded garments found in Montelirio, or the rock crystal and ivory artefacts found there and in other large megalithic tombs.

In terms of its functional characterisation, our sample contains tools used for grinding, or for the production and maintenance of grinding tools. What was being ground? The use-wear analysis suggests that grinding of cereals played a major role, although other foodstuffs may also have been ground. An obvious candidate would be acorns. Elsewhere in Iberia, there is direct evidence for acorns being ground on querns during the Late Neolithic (Juan-Tresserras and Matamala 2005) and they are known to have been a major element in the diet throughout Late Prehistory and Antiquity (García Gómez et al. 2009). Indirect evidence in the form of acorns made of ivory (and possibly amber) suggests this fruit was an important food resource in Copper Age Valencina (García Sanjuán 2017, pp. 241–242).

Analysis of the contexts of deposition leads to some interesting observations. Grinding tools were mostly deposited in pits and basins, and only occasionally in ditches or other more complex negative features. They do not appear in the megalithic monuments of the PP4-Montelirio sector, but almost a third of them came from contexts associated with human remains. The most significant example is Structure UE 136 at Calle Trabajadores, a basin in which 21 macrolithic tools (including 14 quern fragments, 4 hammers/grinders, 2 hammers and 1 grinder) were found in association with a human skull and mandible. This is the largest assemblage of grinding tools found in a single feature. It is also important to note that at PP4-Montelirio a quern fragment was found in association with a complete ceramic vessel in the ditch of Structure 10.024, a ditched enclosure with comparatively large quantities of faunal remains and pottery, perhaps suggesting its role as a stage for gatherings of people. In a number of cases, therefore, grinding tools have been found in 'symbolically-charged' structures.

Also relevant to the discussion of find contexts is the fact that a large proportion of tools display signs of thermal alteration. These signs appear evenly distributed across all seven sectors studied here, which suggests that the circumstances that led to these objects being thermally altered were consistent across the entire area of Valencina and remained stable throughout the entire period of its use. But what were those circumstances? Were tools exposed to fire while they were still in use, or while in the process of being discarded and abandoned? Given that thermal alteration often provokes the cracking and spontaneous flaking of stone, rendering tools unusable, the latter seems a more likely explanation. In that case, exposure to fire should be seen within the context of the practices that led to the discard and deposition of the tools. Although this issue has never been properly studied, traces of combustion, such as ash, charred organic material, rubefacted sediments and burned artefacts are very frequently documented in the pits and shallow basins where most of the Valencina grinding tools are found (see multiple examples in Vargas Jiménez 2004). At Valencina, the evidence for 'residential' structures (huts) with hearths is extremely limited (García Sanjuán and Murillo-Barroso 2013, pp. 126–127). Instead, the use of fire in pits and basins may have been part of formal 'burial', 'closure' or 'abandonment' rituals involving a wide spectrum of elements (human and animal remains, material culture, sediments, etc.). Evidence for the use of fire is widespread in European ditched sites of the 4th and 3rd millennium cal BC. At Sarup, perhaps the best-known example of this type of site, it has been suggested that 'live' flames were buried inside pits and ditches (Andersen 1997, p. 49).

As a hypothesis, the 'ritual' exposure of grinding tools to fire at the time of discard or deposition is consistent with their extremely high degree of fragmentation, especially that of the querns. As noted above, this fragmentation cannot be explained by processes of recycling alone. The absence of complete querns among the subsample of items for which well-defined contextual information exists suggests that the fragmentation is the outcome of a cultural choice and a social practice. This fragmentation may have entailed not a deliberate and 'ritualised' breakage of the objects at the time of deposition – *sensu* Chapman (1999); Chapman and Gaydarska (2007); Valera (2019) – but rather the selection and deposition of fragments. This pattern of fragmentation of querns has been noted elsewhere in Europe (Tsoraki 2007; Graefe et al. 2009, p. 32).

The obvious implication of this discussion is that, at Valencina, querns are not found where they were being used, but where they were deposited – which is quite a different thing. At Los Millares, six large complete saddle querns were found inside a 38 m^2 structure that was interpreted as a space for the processing of cereals (Molina González and Cámara Serrano 2005, p. 71). At Valencina, no such structure has ever been identified. In fact, at Valencina, scarcely any complete saddle querns have been recovered; our sample includes eight, but all come for surface layers or from structures of uncertain type, which raises doubts as to their chronology. As already observed, the rate of fragmentation among querns coming from features securely attributed to the Chalcolithic (excluding surface and/or dubious finds) is extremely high, with up to 87% of them representing less than 25% of the original object.

In summary, the grinding technology from Valencina can be read in different ways. On the one hand, the consistency of the evidence presented here in terms of (i) the high degree of fragmentation, (ii) exposure to fire across the entire assemblage, and (iii) occasional association with the deposition of human remains suggests a specific transference of material culture from the systemic context into the archaeological record (*sensu* Schiffer 1972). This pattern seems to exclude the notion of a ‘Pompeian’ archaeological record at Valencina, reinforcing, instead, the impression of a highly ‘staged’ record.

The selection and fragmentation of the grinding material deposited at Valencina parallels similar observations for other kinds of evidence. For example, the profile of the faunal assemblages in at least two sectors of the site showed that the meatiest anatomical parts of large animals had been selected, suggesting that slaughter did not take place *in situ,* but that the meat was brought to site ready for consumption in feasts and celebrations perhaps in connection with funerals and other rituals (García Sanjuán et al. 2017, p. 250).

On the other hand, we must consider whether the absence of complete quernstones and a deposition pattern limited to broken and fragmentary elements could indicate that all of the complete querns had been curated and removed. Cereals and other foodstuffs may indeed have been ground into flour at Valencina, during shorter or longer episodes of occupation. Huts or houses may have been dismantled after use, with discarded items carefully deposited in pits, but whiole quernstones transported for subsequent use elsewhere. It may indeed be more likely that objects such as these, requiring many hours to manufacture and still offering weeks, months or years of future use, would be curated rather than discarded. Settlement activity may have regularly shifted between areas within Valencina, and portable but still usable items such as querns moved around as part of this process. The complete examples from surface contexts may represent querns that had indeed been discarded, but only in the final stages of activity at Valencina, when the site itself was abandoned.

Once more, this raises the question of what kind of site Valencina represents (see previous discussion in García Sanjuán 2013; García Sanjuán et al. 2017; García Sanjuán et al. 2018b). It may have been a place of congregation, ritual and ceremony, as exemplified by the spectacular funerary monuments and their assemblages. At the same time, the presence of grinding slabs and similar household equipment would be consistent with domestic life. The ‘staged’ deposition of the fragmentary grinding tools indicates a ritualization of practice that is widely documented in prehistoric contexts, and no sharp distinction between ceremonial, symbolic and ‘mundane’ activities should indeed be expected. Valencina is nonetheless a special site, posing unique challenges of interpretation through its size, its longevity, and its remarkable suite of archaeological features and materials.

The results reported in this paper have significant implications for future research and understanding of European Late Prehistoric mega-sites. Macrolithic technology in general, and grinding tools in particular, provide direct insight into the kind of occupation to which these sites were witness, and the kind of social practices they staged. At Fuente Álamo, a 1.5-hectare settlement in the semi-arid Spanish southeast, 2300 whole querns were found (Risch 2002). Several hundred years earlier, Valencina, a site four hundred times larger, had (if our sample is a reliable indicator) virtually no whole querns. The economic and social role of milling and the patterns of discard and deposition of this fundamental technology seem to have been radically different at these two sites. Was that difference more generally the case for Late Neolithic–Copper Age societies on the one hand, and Early Bronze Age ones on the other? If anything, the results described above point more towards Valencina being home to large episodic gatherings, of the kind proposed for Trypillia mega-sites such as Nebelivka in the Ukraine (Chapman and Gaydarska 2019), rather than a stable proto-urban settlement (a problem we have already discussed: García Sanjuán et al. 2017). Needless to say, only future research following the kind of multi-disciplinary approach adopted here will enable these issues to be resolved.

Acknowledgment

We would like to thank Roberto Risch and Marina Eguiluz for their insightful comments on an earlier draft of this paper. We also would like to thank two anonymous reviewers for their helpful suggestions towards the revision of the manuscript.

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